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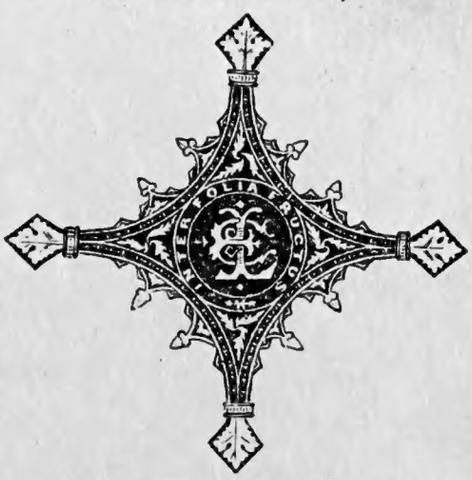

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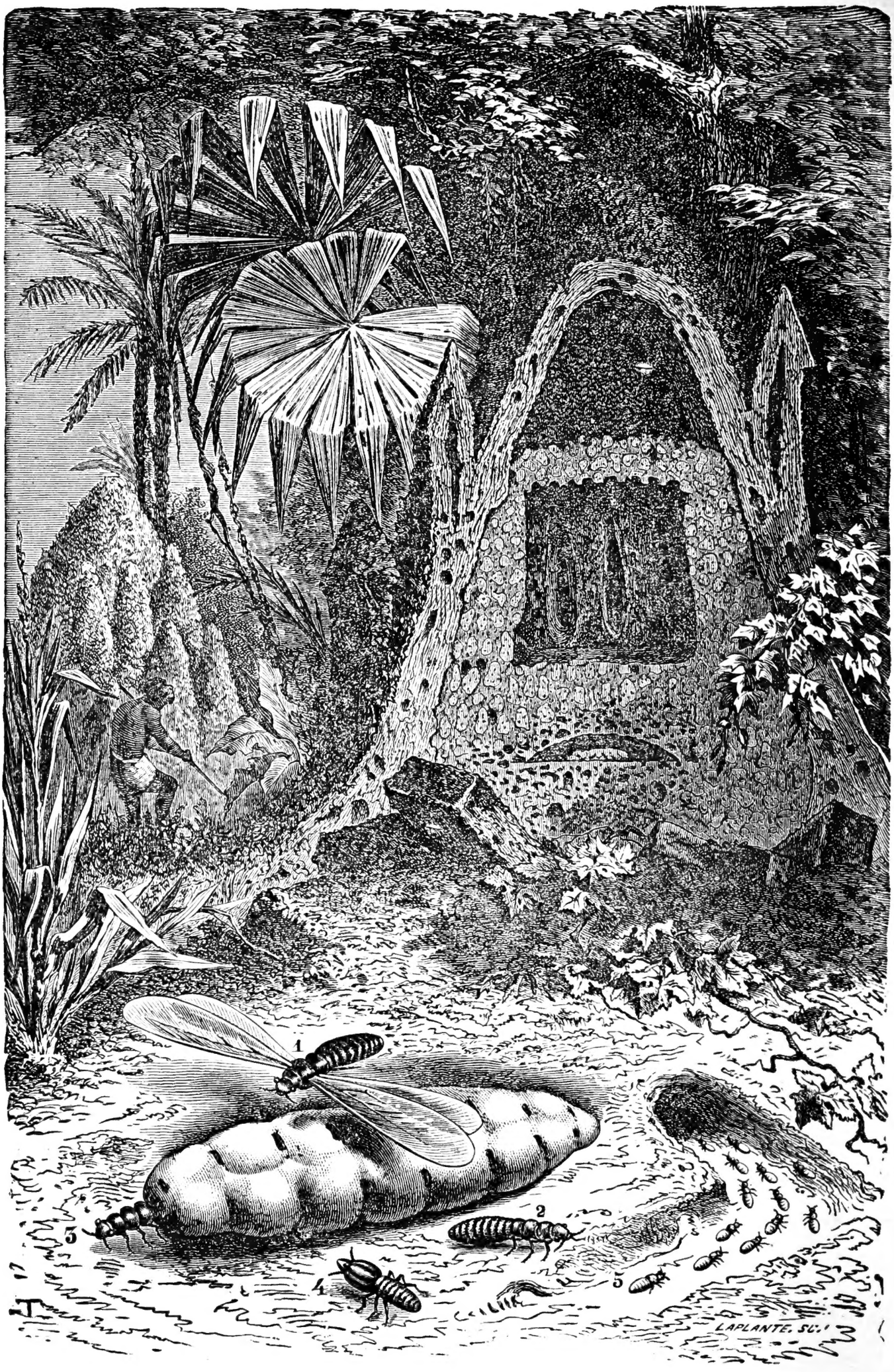


INSECTS AS ARCHITECTS.

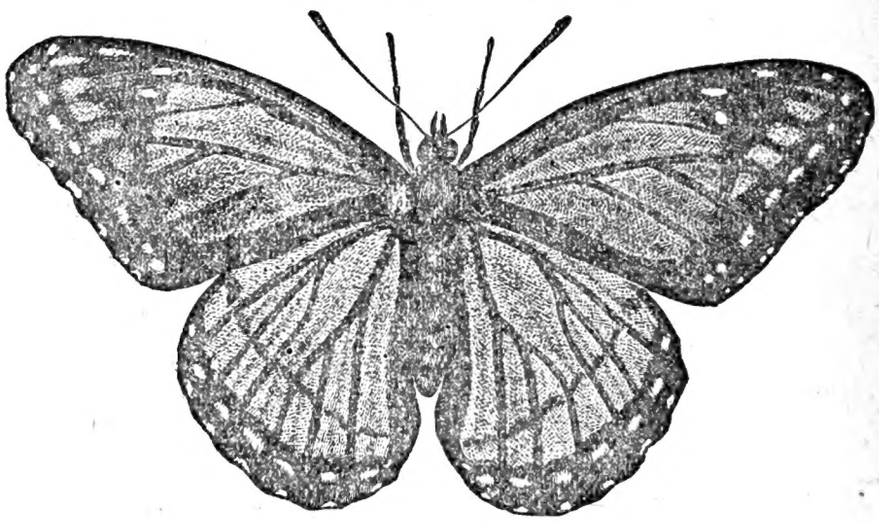
Bates says that a large number of the species of Heliconidæ "are accompanied in the districts they inhabit by other species which counterfeit them in the way described. The imitators belong to the following groups:—Papilio, Pieris, Euterpe, and Leptalis (family Papilionidæ), Protogonius (Nymphalidæ), Ithomeis, Erycinidæ, Castnia (Castniadæ), Dioptis, Pericopis, Hyelosia and other genera (Bombycidæ moths). I conclude that the Heliconidæ are the *objects imitated*, because they all have the same family facies, whilst the analogous species are dissimilar to their nearest allies—perverted, as it were, to produce the resemblance from the normal facies of the genus or family to which they severally belong. The resemblance is so close, that it is only after long practice that the true can be distinguished from the counterfeit, when on the wing in their native forests. I was never able to distinguish the Leptalides from the species they imitated, although they belong to a family totally different in structure and metamorphosis from the Heliconidæ, without examining them closely after capture. They fly in the same parts of the forests, and generally in company with the species they mimic."

In the United States we have a similar example, the only one known in this country. The *Danaus Disippus* is one of our most common butterflies. It is closely copied by the *Limenitis Archippus* (Fig. 226, from Tenney's Zoology), which is unlike in color every other known species of its genus. The Archippus enjoys immunity from the attacks of birds on account of its pungent odor, which is supposed to be disagreeable to them; hence it is very abundant. The Disippus butterfly, on the other hand, which is inodorous, is supposed to be mistaken by the birds for the Archippus, and thus multiplies in as great numbers as the pattern it copies. Such are the opinions of these distinguished writers.

It will be noticed that the Heliconidæ are regarded by Mr. Bates, and in this respect Mr. Trimen agrees with him,

as standing at the head of the group of butterflies, the Papilio usually being assigned to this position. Here, then, the mimickers are possibly lower in rank than the butterflies they mimic. This is certainly the case with the Castnia and the moths mentioned by Mr. Bates, and bears out our idea that the mimickers may have been produced in an age anterior to the origin of the Heliconidæ, and that the causes which produced the one perhaps originated the other. The

FIG. 226.



Limenitis Archippus.

mimickers created in a former geological period may have been preserved by virtue of their resemblance to butterflies originating at a later date.

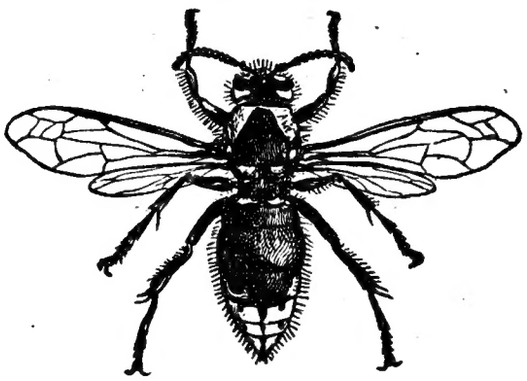
Many of the Bombycid moths are remarkable mimics of other moths, and this group, with the wide gaps in it, may be compared to the Neuroptera with their isolated genera and families. I regard the Bombycids as an ancient family in which time has made many inroads, and the relics which have come down to us may have owed their preservation largely to the protective mimicry of the caterpillars and cocoons to leaves and other objects, and of the moths to other moths.

Assuming, then, that protective mimicry has been an important factor in the preservation of species, we will exam-

ine a number of cases, some of which are not recorded so far as the writer is aware, but which any one can see for himself in his rambles out of doors.

The humble bees are mimicked by the Apathus, which takes up its abode in their nests. The peculiar relations existing between the Apathus and its host are not well understood. The Apathus is closely related to the humble bee, only differing from it in the structure of the jaws and hind legs, disabling it from gathering honey and pollen and caring for its young. Another well known mimic of humble bees is the Volucella, a large, plump, hirsute fly, in form and color closely copying the bee. Protected by this resemblance they enter the nests of their hosts, and their young devour the young bees. Bees are also mimicked by certain Syrphus flies (see Fig. 107) and by Laphria flies. The wasps are imitated often very closely by certain Syrphus flies (Fig. 26, *a*). The most extraordinary case of this kind is a Syrphus fly called Spilomyia. I once noticed this fly resting on a leaf in northern Maine, and involuntarily drew back, supposing it to be a white faced wasp (*Vespa maculata*, Fig. 227). It is smooth-bodied with the abdomen nearly cylindrical and thoroughly wasp-like. The position and form of the markings are almost exactly as in the wasp; the face is white, and the eyes are banded with white in imitation of the white orbits of the wasps. Even the abdomen or hind body is banded only towards the tip as in the wasp, while the legs are slashed with white much as in the wasp. Another Syrphus (*Epopter vittatus*), with a cylindrical body, is banded with bright yellow and resembles the *Vespa vulgaris*, while there are other species, such as *Doros balyrus*, which

FIG. 227.



Vespa maculata.

resemble the Odynerus wasp. Other forms recall the mason bees, Osmia, and two green species (*Syrphus obscurus* and *Sargus obscurus*) recall Ceratina, the little green bee which tunnels the blackberry and syringa. The Euglossa, a bee with a remarkably long tongue, is mimicked by Pangonia, equally favored with a long beak. Wasps are also mimicked by lower Hymenoptera, as the large Chalcis fly, Leucospis (Fig. 228) which is so unlike others of its family. The Trypoxylon wasp with its club-shaped body is copied by the Conops, even to the peculiar hue of the front edge of the wings. Descending the scale of hymenopterous life we come to the Pompilus (Fig. 61), which is mimicked by the large black Mydas fly, whose antennæ are unusually long and hymenopterous-like. Certain ants are mimicked by species of Clerus beetles, which are colored in the same manner and run rapidly on the branches of bushes very much like ants. A certain beetle is called Formicomus from its resemblance to Formica, the ant.

FIG. 228.

Leucospis.

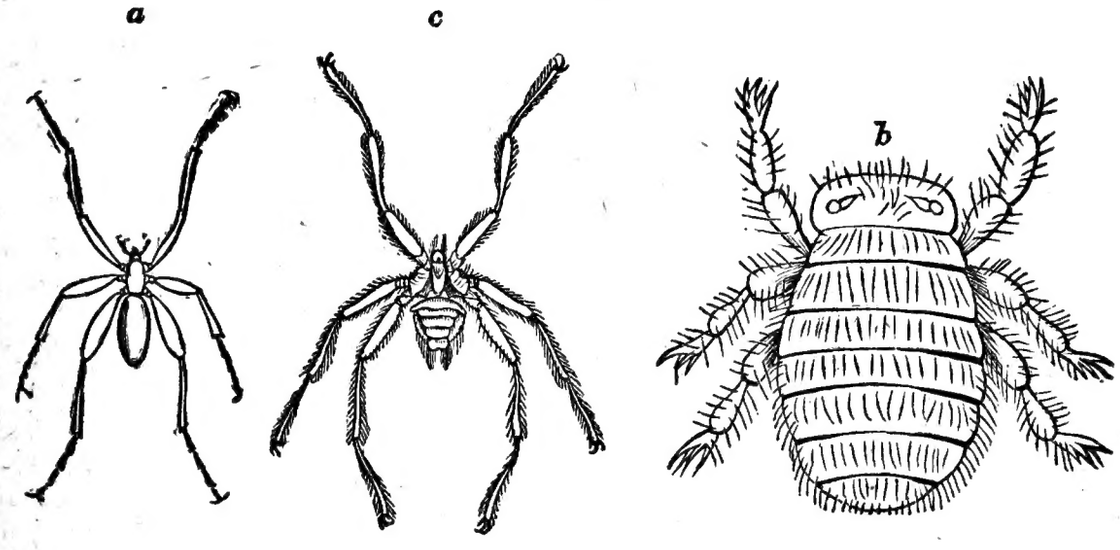
Among butterflies, the Papilio or swallow-tailed butterfly is very closely mimicked, both in form and color, by the highly colored swallow-tailed geometrid moth, Urania, and there is another geometrid moth that recalls the tailed Thecla. The Thyris moth is copied by the Desmia, a little black Pyralid moth, with large white spots on the wings.

On the other hand there are some moths which resemble so closely those of families below them that to this day in some cases entomologists have been mistaken in regard to them. The Doryodes with its feathered antennæ is in reality an owlet (Noctuid) moth, but has until recently been regarded as a geometrid moth allied to Aspilates. So with Boletobia and Pachycnemia, which are also Noctuid moths with analogies to the geometrid moths. Among the Bombycid moths are such forms as Euphanessa and Crocota which

remind us of geometrid moths, and they fly by day associated with them.

The wingless flies nearly always show a tendency to resemble spiders, from the wingless gnat-like Chionea (Fig. 229 *a*) down to the sheep tick, the bat tick (Fig. 229 *c*), and the bee louse (Fig. 229 *b*). I do not regard these, however, as cases of protective mimicry, but interesting

FIG. 229.



Chionea. Bat tick. Bee louse.

analogies resulting from the loss of wings and other degradational characters induced by their usually parasitic mode of life.

A singular case of mimicry may be observed in the moth Lycomorpha, so named by Dr. Harris from its resemblance when at rest to Lycus, which possesses broad wing-covers (elytra). The fore wings of the moth are shaped like the elytra of the beetle, the veins being much raised, like the ridges on the beetle's wings, while the arrangement of the colors is almost identical, and the antennæ of the moth are broad and flattened like those of the beetle.

The burrows of the mole cricket are, in North Carolina, as I have been informed by Mr. Shute, tenanted by a large bug, which has fore feet somewhat like those of the mole

cricket. Here the change in form has been evidently induced by its fossorial life, and we should not perhaps regard this as a case of protective mimicry. There are other bugs, of large size, with the legs provided with flattened expansions, like some long-horned beetles.

11. Insects as Architects.

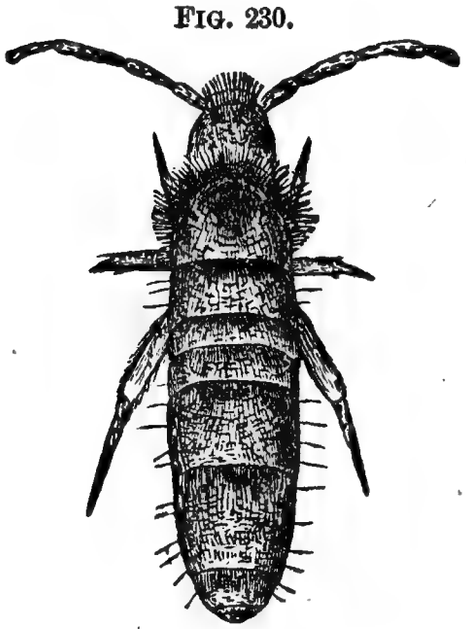
AN historical sketch of human architecture would scarcely begin with a description of the capitol at Washington, or of Westminster Abbey, or the still incomplete cathedral of Cologne, but would rather extend back to the earliest forms of human shelter, even to the pile dwellings of prehistoric Switzerland; nor would the historian disregard the rock shelters of Europe and this country, or the caves of Dordogne. In his accounts of the rise of the art of building he would be obliged to treat the subject after the method of the paleontologist, and reconstruct the primitive dwellings of the men of the reindeer period from the scanty relics of their age, with the aid of the huts and wigwams of savage tribes now living. Working out these problems, he would then reconstruct in the imagination the vast structure of Stonehenge, the palaces of the Aztecs, and would then be prepared to deal with the rise of architecture in Egypt, India and Greece.

So we may study the subject of insect architecture in the light of paleontology, and finding in the rocks the remains of lost tribes, judge what manner of builders they might have been by the work of their survivors of the present day, whose forms for aught we know are little superior to those of their ancestors of Devonian times, just as the savage of to-day is perhaps scarcely a step in advance of the wearer of the skull of Tuolumne valley, or the cave of Neanderthal.

Without much doubt the first cave-dweller was some Poduran (Fig. 230) or a Campodea-like being, if such lived in Presilurian times. They were the troglodytes of that misty period, living in holes in the earth, which wound their devi-

ous way under stones. There have been found in rocks of the coal period spider-like forms supposed to be allied to our modern harvest men, or the cave dweller of Wyandotte Cave (Fig. 231, after Cope), whose out-of-door relatives are said by Simon, a French entomologist, to burrow several feet deep in the porous soil of southern Europe. Associated with these fossils are found the remains of undoubted spiders, and in all likelihood they spun silken nests, and thus

FIG. 230.



Podura.

FIG. 231.

Erebomaster.

anticipated eons ago the light graceful iron work of our suspension bridges, crystal palaces and mammoth railroad stations.

But as early as the Devonian period, the time which ushered in the Coal epoch, when the ferns and land plants made their appearance, and the huge ganoids and sharks disported in the seas, at this early date insects resembling the May fly, but much larger, fluttered over the low shores and sluggish streams of our continent. Since they must have had the same organization as the modern Ephemera (see Figs. 117, 118) it is reasonable to suppose that they had the same habits. The first architects, then, so far as fossil evidence goes, in their larval stage lived in burrows con-

structed in the mud, or in rude tunnels beneath stones at the bottom of streams and ponds, or they supported their arched ways on the stalks of aquatic plants. These builders of Devonian times, in a way unconscious to themselves, tried the strength of their rude building material, practised the art of the mason, and applied the principles of the geometrician in their rough and ready mechanics.

In the Coal formation we find wings of fossil insects closely resembling our white ants, and belonging, perhaps, in the same family. Now some species of these insects are among the most skilled architects in the insect world. We shall see farther on how remarkable their large roomy dwellings are. Others construct tunnels in decayed trees. Our common white ant (*Termes flavipes*) is known either to mine the roots of grape vines, the trunks of elms, pine stumps, or to run secret galleries in the sills of houses, or to live under flat stones, with nests apparently like those of ants found in the same situations. Different species so far as we know have quite different habits. For example, the nests of *Termes arborum* are described by Smeathman as "surrounding the branch of a tree at the height of seventy or eighty feet; and (though but rarely of so large a size) as big as a very great sugar cask. They are composed of small particles of wood and the various gums and juices of trees, combined with, perhaps, those of the animals, and worked by these little industrious creatures into a paste, and so moulded into innumerable little cells of very different and irregular forms. . . . . These nests are very compact, and so strongly attached to the boughs on which they are fixed that there is no detaching them but by cutting them in pieces, or sawing off the branch." The nest communicates with the ground by covered ways leading to the roots of the trees. Again he describes some nests that resemble the complex nests of *Termes bellicosus*, but are smaller and of simpler construction. They are built in sandy plains, and

are "composed of a black mud, which is brought from a few inches below the white sand, and are built in the form of an imperfect cone, or bell-shaped, having their tops rounded. These nests are generally about four or five feet high." (Smeathman.) Other nests are built in the form of a mushroom.

The most elaborate architectural works, perhaps, undertaken by any insects are the nests of the *Termes bellicosus*, observed by Smeathman. Our figure (from Figuier, after Smeathman) will give an idea of the nest and its interior, with the Termes family grouped in the foreground. Smeathman, a traveller in Guinea, who published his account of these insects in 1781, claims, and we think with reason, that "the Termites resemble the ants also in their provident and diligent labor, but surpass them, as well as the bees, wasps, beavers and all other animals which I have ever heard of, in the arts of building, as much as the Europeans excel the least cultivated among the savages. It is more than probable they excel them as much in sagacity and the arts of government; it is certain they show more substantial instances of their ingenuity and industry than any other animals; and do in fact lay up vast magazines of provisions and other stores; a degree of prudence which has of late years been denied, perhaps without reason, to the ants."

The nests or "termitary" of this white ant are more or less conical or sugar-loaf-shaped, rising from ten to twelve feet above the surface of the ground. Indeed, they are said to be still higher by Jobson in his "History of Gambia," quoted by Smeathman as follows: "The Ant hills are remarkable cast up in those parts by Pismires, some of them twenty foot in height, of compasse to contayne a dozen men, with the heat of the sun baked into that hardnesse, that we used to hide ourselves in the ragged tops of them, when we took up stands to shoot at deere or wild beasts." (Purchas's Pilgrims, vol. ii, p. 1570.) Smeathman tells us

that on those he saw four men could stand with ease. The nests are ornamented with numerous conical turrets, sometimes four or five feet high. The walls of this dome are exceedingly hard and form a sort of shell protecting an interior building, divided into "an amazing number of apartments for the king and queen, and the nursing of their numerous progeny; or for magazines, which are always found well filled with stores and provisions." These colossal hills begin as little turrets a foot high; others are built near them, the highest one being built in the middle, until the spaces between are filled up and the whole built together into a single dome. This outer shell or dome not only protects and shelters the rooms within, but maintains an equitable temperature and moisture within, "very necessary for hatching the eggs and cherishing the young ones."

In the centre of the inner building near the base is the oven-like royal chamber, which is enlarged from an inch to six or eight inches or more in the clear as the queen increases in size. Here the king and queen are kept willing prisoners, as the entrances are only large enough to admit the workers which are much smaller. The royal chamber is surrounded by multitudes of smaller apartments which connect with the larger magazines and nurseries. The magazines are filled with provisions consisting of the gum of trees in small tears, resembling the sugar about preserved fruits. The nurseries containing the eggs and young are built of "wooden materials seemingly joined together with gums" and situated around the royal chamber.

All these apartments lead by arched passages into an open area or rotunda under the dome, which is compared by Smeathman to the nave of a cathedral. This nave "is surrounded by three or four very large Gothic-shaped arches, which are sometimes two or three feet high next the front of the area, but diminish very rapidly as they recede from thence like the arches of aisles in perspectives, and are soon

lost among the innumerable chambers and nurseries behind them." This nave is covered with a roof sufficient to keep the room dry during the heavy rains. This roof is not exactly flat because the workers "are always adding to it by building more chambers and nurseries; so that the divisions or columns between the future arched apartments resemble the pinnacles upon the fronts of some old buildings, and demand particular notice as affording one proof that for the most part the insects project their arches, and do not make them, as I imagined for a long time, by excavation."

The floor of the nave is very thick and forms the roof of the royal chamber, though containing several nurseries and magazines. "It is likewise water proof, and contrived, as far as I could guess, to let the water off, if it should get in, and run over by some short way into the subterraneous passages which run under the lowest apartments in the hill in various directions, and are of an astonishing size, being wider than the bore of a great cannon. I have a memorandum of one I measured, perfectly cylindrical, and thirteen inches in diameter."

These subterraneous passages or galleries are lined very thick with the same kind of clay of which the hill is composed, and ascend the inside of the outward shell in a spiral manner, and winding round the whole building up to the top, intersect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, etc., or communicating thereto by other galleries of different bores or diameters, either circular or oval." From these large galleries smaller ones extend to various parts of the building, and a great many run three or four feet under ground, where the Termites obtain the fine soil with which they build their nests. Other galleries," adds Smeathman, "ascend and lead out horizontally on every side, and are carried under ground near to the surface a vast distance; for if you destroy all

the nests within one hundred yards of your house, the inhabitants of those which are left unmolested farther off will nevertheless carry on their subterraneous galleries, and invade the goods and merchandizes contained in it by sap and mine, and do great mischief, if you are not very circumspect." Smeathman then remarks that the galleries are necessarily large, as they are the "great thoroughfares for all the laborers and soldiers going forth or returning upon any business whatever, whether fetching clay, wood, water or provisions; and they are certainly well calculated for the purposes to which they are applied, by the spiral slope which is given them, for if they were perpendicular the laborers would not be able to carry on their building with so much facility, as they ascend a perpendicular with great difficulty, and the soldiers can scarce do it at all. It is on this account that sometimes a road like a ledge is made on the perpendicular side of any part of the building within their hill, which is flat on the upper surface, and half an inch wide, and ascends gradually like a staircase, or like those roads which are cut on the sides of hills and mountains, that would otherwise be inaccessible; by which, and similar contrivances, they travel with great facility to every interior part.

"This too is probably the cause of their building a kind of bridge of one vast arch, which answers the purpose of a flight of stairs from the floor of the area to some opening on the side of one of the columns which support the great arches, which must shorten the distance exceedingly to those labourers who have the eggs to carry from the royal chamber to some of the upper nurseries, which in some hills would be four or five feet in the straightest line and much more if carried through all the winding passages which lead through the inner chambers and apartments."

Whether the work of these white ants is due to the operations of a "blind instinct" or unconscious automatism may well be doubted. It should be borne in mind also that the

insects belong to the lowest division of the winged insects, and, even geologically speaking, to a very ancient stock. It is significant to find developed in them such a high degree of architectural skill.

The mechanical ingenuity of the case worms is shown in the construction of their cases. These are ancient types of insect forms thought to be in some respects similar to those occurring in the coal formation, while undoubted caddis-flies occurred in the Wealden strata of the Lower Cretaceous formation. Sir Charles Lyell assures us that "a large species of caddis-worm, which swarmed in the Eocene lakes of Auvergne in France, was accustomed to attach to its dwelling the shells of a small spiral univalve of the genus Paludina." It must have resembled the cases of the British *Limnophilus flavicornis*, whose case (Fig. 232) is covered with little fresh water snail shells. Other examples of the work of these interesting insects are given on page 132. They gather bits of leaves or sticks, or particles of gravel, with their jaws, and arrange them around their body, covering their hind body first and then building on to the anterior end, gluing the particles together by means of a silky secretion. They probably do not use their fore legs in this process, at least the clothes moth does not in constructing a similar case. Other cases are made by rolling up a strip of leaf deftly cut out of the required length and width, as seen in Fig. 92, while others, more careless, attach broad, irregular pieces to their cases.

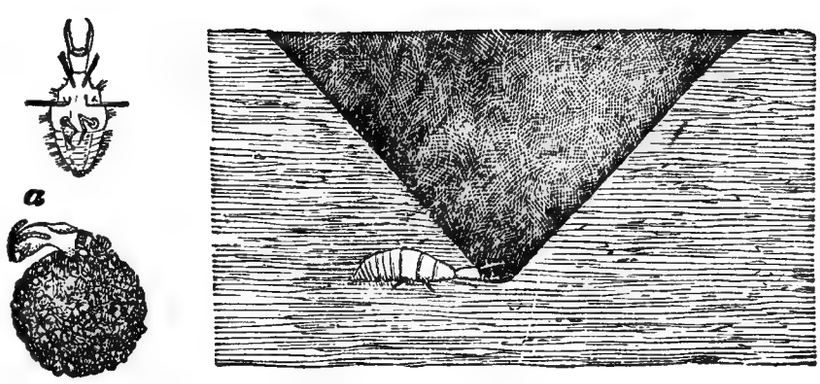
FIG. 232.

Case worm.

Another net-veined insect which shows much ingenuity in the construction of its dwelling, and much low cunning in providing itself with food, is the ant lion. This is the larva of the Myrmeleo. Its body is broad and flat, armed with enormous scissor-like jaws which project straight out from the head. It lives in colonies, sometimes numbering over

six hundred individuals, each lying at the bottom of its hole. Mr. Emerton has described, in the "American Naturalist" (iv, p. 705), the habits of our *Myrmeleo immaculatus* (Fig. 233, with the larva seen from beneath, and the pupa). It digs a pit in the sand an inch deep and two inches in diameter. Mr. Emerton thinks the ant lion begins its hole by making a circle and afterwards throwing out the sand from the centre. "In digging he used his flat head and jaws, which were pushed under several grains of sand and then jerked upwards, throwing their load sometimes as far as six inches, and always far enough to avoid leaving a ridge around the pitfall. When the pit was finished he was entirely concealed beneath it, as in Fig. 233, except his jaws,

FIG. 233.



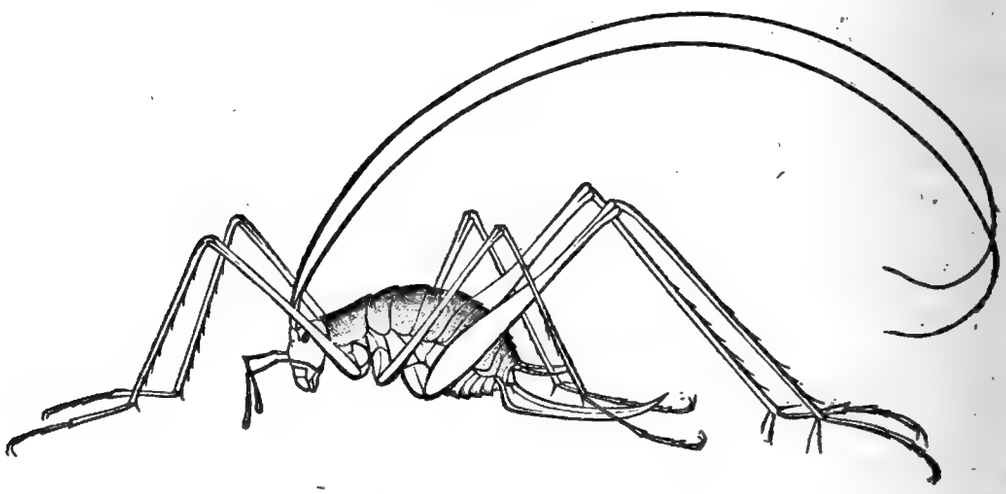
Ant Lion and its pit.

which were spread apart horizontally at the bottom. The surface of the pit being as steep as the sand could be piled up was very easily disturbed, and when an insect ventured over the edge the ant-lion was apprised of it at once by the falling sand. He immediately began to throw up sand from the bottom, deepening the pit, and so causing the sand to slip down from the sides and the insect with it. The ant-lion seized it with his long jaws and held it up above his head, until he had sucked all he wanted from it, when he threw the remainder out of the hole and repaired the trap. . . . After eating he became more timid and sometimes would not take a second insect. If, however, several were

put into the pit at once, he would bite one after the other until all were killed, before deciding on which to begin."

While the grasshoppers do not construct nests, they have various methods of securely depositing their eggs either in the earth or in rotten wood or on the surface of leaves. The wingless grasshoppers avail themselves of rocks as shelters, a notable example being the wingless grasshopper of Mammoth and other caves in Kentucky (Fig. 234). The English cricket is said by White, in his "Natural History of Selborn," to form burrows in the earth, but this habit has not yet been discovered in our American species. The mole cricket, however, is known to burrow in damp places in this country,

FIG. 234.



Cave Grasshopper.

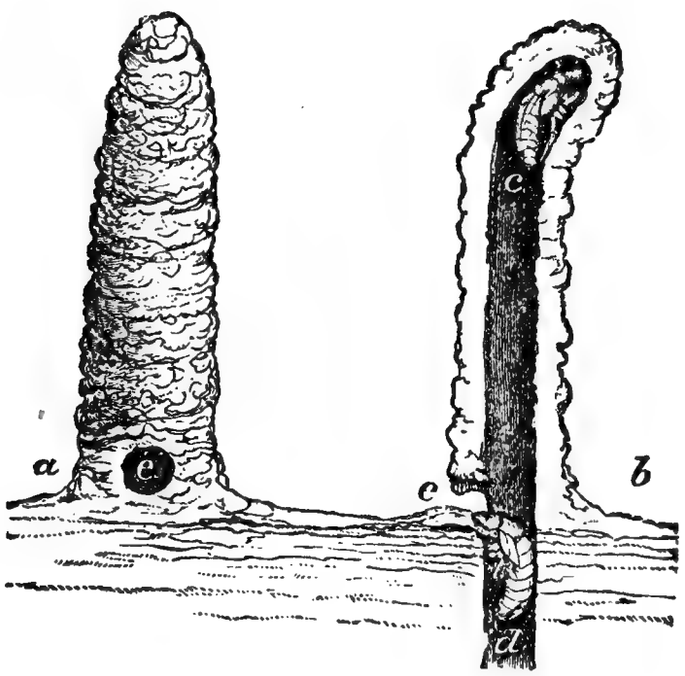
as well as Europe, where it forms an oven-like chamber in which it deposits about a hundred eggs. It also constructs extensive galleries, similar to, but smaller than, those of the mole. The tunnel runs just under the surface of the soil, and may be detected by the slightly raised ridge of soil like that made by the mole.

Among the bugs (Hemiptera) the only species we can now recall as constructing a domicile is the young of the seventeen-year Cicada. Our figure (235, after Riley) represents the conical nests raised above the surface of the soil in wet and damp places, rising from four to six inches above

the ground, with a hole (*e*) at the base. Mr. Rathvon, who observed this fact, says that the pupæ await in the upper end of these chambers their time of transformation into the winged state, and when about to come from the ground, move backwards down the tube to below the level of the earth as at *d*, "and issuing forth from the orifice would attach themselves to the first object at hand, and undergo their transformations in the usual manner."

Many plant lice allied to the Aphis, by their punctures cause the adjacent parts of the leaf to curl over and conceal

FIG. 235.



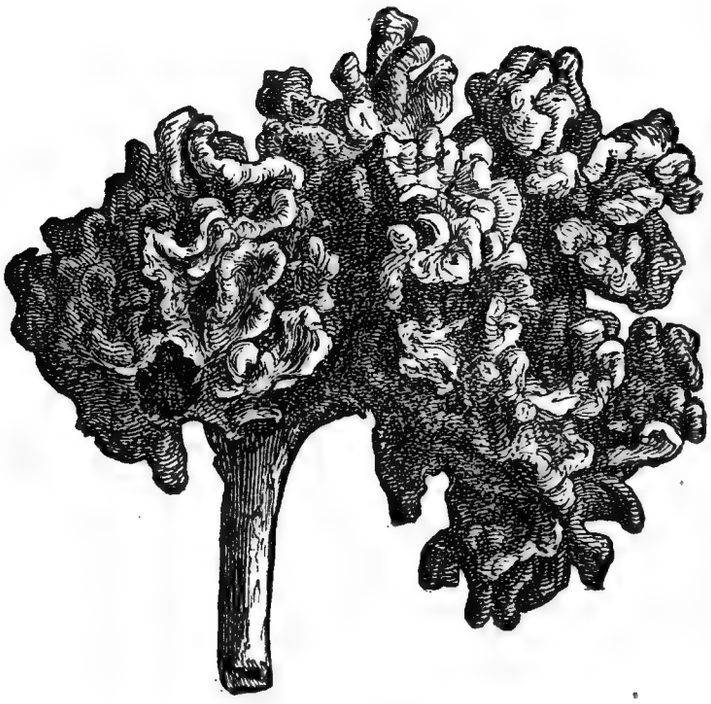
Young 17-year Cicada and its nest.

them, or even give rise to the true galls, as elaborate as those of the gall fly. A kind of Pemphigus forms on the sumac the irregular growth represented by figure 236 (after Riley). The cock's-comb elm gall (Fig. 237, after Riley) often occurs in great numbers on the leaves of the white elm. "By the end of June or the beginning," says Mr. Walsh, "the gall becomes full of winged plant-lice, when the slit on the upper side of the leaf, through which the mother plant-louse built up the gall early in the spring, gapes open and

allows the insects to escape into the open air." These galls can scarcely be regarded as evidences of architectural skill, as they are indirectly due to the simple punctures of the beak of the insect, not to an intellectual act.

Among the beetles we shall not find evidence of any considerable skill in building. The habit of the Chlamys of building a compact little case has already been referred to. Its case is black, and appears to be formed of little pellets of excrement, with a seam along the middle of the under

FIG. 236.



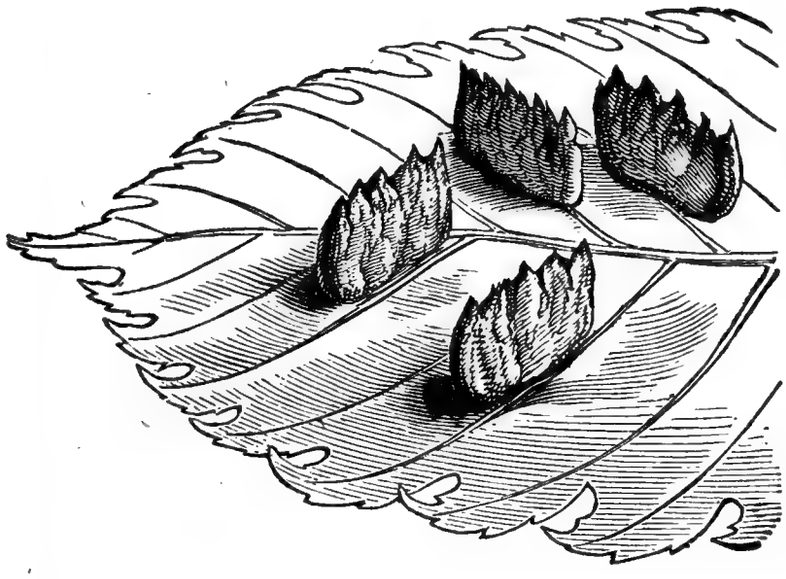
Sumac gall.

side, which readily spreads open when the sac is pressed. The case is slightly contracted at the entrance, where the pellets are a little larger than elsewhere.

The weevils are the lowest of the beetles, and yet they display in some cases great ingenuity in providing appropriate places in which to lay their eggs. I have often watched the doings of the *Attelabus rhois* (Fig. 238 represents another species, *A. analis*) while rolling up the leaves of the alder. Late in June and during the early part of July in

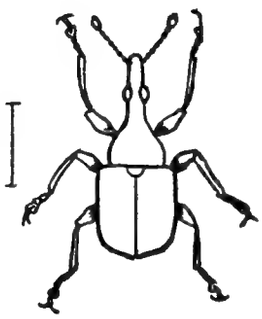
Maine I observed the female while engaged in making one of these singular thimble-like rolls. When about to deposit an egg, she picks up a leaf with her mandibles, and begins to cut with her jaws a slit near the base of the leaf on each side of the midrib, and at right angles to it, so that the leaf may be folded together. Before beginning to roll up the leaf she gnaws the stem nearly off, so that after the roll is made, and has dried for perhaps a day it is easily detached by the wind and falls to the ground. Then folding the leaf, she tightly rolls it up with her jaws and legs, neatly tucking in the ends, until a compact cylindrical solid mass

FIG. 237.



Cock's-comb gall.

FIG.



Attelabus.

is formed. Before the roll is completed she deposits a single egg, rarely two, in the middle, next to the midrib, where it lies loose in a little cavity. While she is thus engaged, her partner, a little smaller, may often be seen watching her from the other end of the leaf, but never lending his aid, as in the case of the timber beetles. The roll serves as a mass of food for the young grub to feed upon, and may be regarded as an artificial bud.

The larvæ of the Tiger beetles have the requisite instinct to make deep tubular pits in which they lie in wait for their

prey. The construction of their nests does not require so much intelligence as is shown by the ant lion. The larva is a hideous being, with a large horn on its back, by which it is enabled to prop itself up in its hole.

None of the flies are architects. Some involuntarily form galls of various shapes, in which the maggots are domiciled. For example, the gall-fly of the willow forms the familiar pine-cone-like swelling (Fig. 239) found on willow twigs, while another kind forms a mass of willow leaves like the

FIG. 239.

Willow gall.

FIG. 240.

Cabbage willow gall.

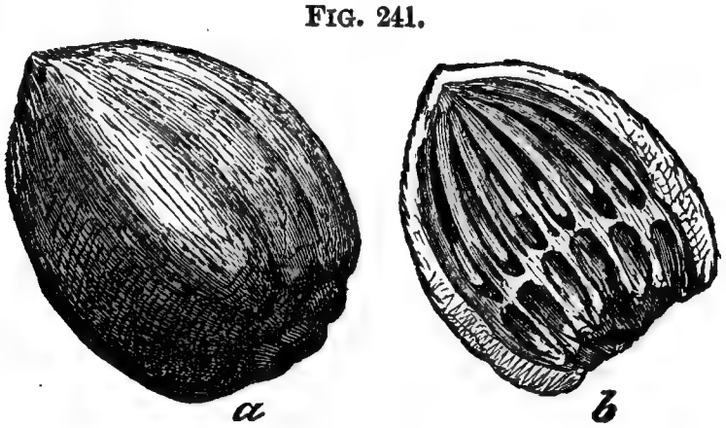
sprouts on a cabbage (Fig. 240). The many-chambered gall of the gall-gnat of the grape vine is represented by figure 241 (this and the two preceding figures from Riley), and Mr. Riley has delineated the filbert gall which grows in large masses on the grape vine (Fig. 242, representing a mass of them of the natural size).

Among the caterpillars of the moths are many of the smaller kinds which mine the leaves of plants, or tunnel the stems; others, more skilful, cut out portions of leaves and

convert them into sacks which they bear about with them, much as in the caddis worms. The young clothes moth (Fig. 243, *a*, its sack; *b*, chrysalis) bites off pieces of the woollen cloth on which it feeds, sticks them together by means of a silky secretion, and thus forms a close, dense sac. As it grows, instead of throwing away the sac it has outgrown, it makes a slit on each side, fills in the rent with new material, and adds more to the mouth, thus enlarging and refitting its house.

Certain small caterpillars of the Acrobasis and other allied genera economize their excrement, constructing between the

FIG. 241.



Many-chambered Grape Gall.

leaves of the birches, on which they feed, little trumpet-shaped cases out of the little black pellets.

The case of the "basket worm" is a curious object. Fig. 244 (*a*, moth; *b*, wingless female; *c*, larva; *d*, case) represents the different stages of growth of a small species found in Florida by Mr. T. Glover. Our common basket worm is a familiar object in the middle and southern states. Its case is about two inches in length, and while the interior is lined densely with silk, on the outside are stuck pieces of cedar twigs and leaves, sometimes half an inch in length. We have seen the young just after leaving the egg beginning to build their cases, which are at first broad and shallow like a basket; and it is a comical sight to see the little tiny worms creeping rapidly along, their tails held straight up in

the air, capped by this basket, reminding one of a small boy walking along with a large bushel basket over his head.

Then there are the tent caterpillars, which spin from their mouths an immense quantity of silk, out of which they build large tents between the branches of trees, and run rope-walks along the upper side of all the branches leading away

FIG. 242.

Filbert Grape Gall.

from their tent. The nest of a species of Tortrix which lives on the wild cherry consists of a large mass of leaves sewed together with silk, forming a shelter from the heat and rain and a protection from the birds.

There are numberless modifications of leaf-rolling habits among the smaller caterpillars, but after all no insects, with

the exception of the Termites, present such evidences of mechanical skill as the bees and wasps and ants. The Hymenoptera, of which they are the most familiar examples, were among the latest insects to appear on the surface of the earth. The lower forms, so far as the scanty records show, appeared first in the Jurassic rocks, while the ants are first found in the amber of the Tertiary period, so that the ants and wasps and bees were in all probability among the latest insect creations. This inference is borne out by the fact that the individuals and species are very abundant. Did they belong to an ancient stock their numbers would have been thinned out.

The lowest hymenopterous insect which lives in a house of its own, not, however, made with its own hands, is a kind

FIG. 243.

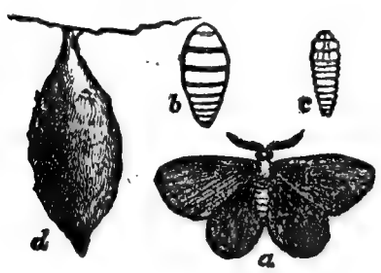
Clothes Moth.

of saw-fly (Euura), which constructs a gall. The female lays an egg in the bud of a willow; the presence of the egg sets up an irritation, causes an unnatural enlargement of the bud-leaves, until a round swelling or tumor is formed, in which the false-caterpillar lives and feeds on the walls of its house, which grows with its growth. Mr. Walsh has studied these gall saw-flies. The gall in which *Euura orbitalis* lives is at first a bud which is enlarged two or three times its natural size before it unfolds in spring. In the autumn it bores through the walls of its dwelling, and descends to the ground, burrowing an inch deep below the surface. Here it

spins a thin, silken, whitish cocoon. Other species take up their abode in galls made by two-winged gall gnats, and are hence called guest or "inquiline" saw-flies. These galls are sometimes inhabited also by a caterpillar, so that we have a saw-fly caterpillar, a true caterpillar, and a maggot making use of the same kind of gall. They do not, however, crowd into the same domicile at once. In this case at any rate nature does not set the laws of hygiene at defiance, and crowd two or three families in a single room. The necessities of modern civilization, or an outgrowth from it in our cities, crowd several families in a single room. Is not a human life of as much account as a caterpillar's?

The saw-flies with their exceptional gall-making habits anticipate in nature the true gall flies, those singular beings to whom a gall is their world, and the gall of bitterness a perennial fountain of nectar. To these little white maggots, the young gall flies, the poor scribbler who is obliged like Douglas Jerrold to feed his family "out of an inkstand," owes his all. Quite unconscious of the responsibility resting upon him, our maggot, truly an "unconscious automaton," by its simple presence in the leaf or stem, and with no more intention to be an agent in bringing about a desired result than though it were a grain of sand, lies passively in its cell, while the growth-force of the plant erects a house over and around this foreign body. No more intellectual act is needed on the part of the guest than in its unconscious host, the plant. The case of the gall maggot is an excellent example of "unconscious automatism," while I imagine the reader will agree with me that the case of the white ant, or the true ants, as well as many bees and wasps, is of an entirely different order and carries us into a sphere where the sensibilities, the will, and the intellect exert at least some force.

FIG. 244.

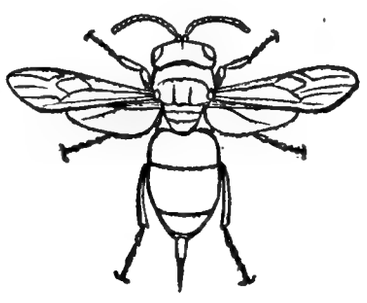


Basket Worm.

The largest gall we have is made by the *Cynips confluens*, found on the scrub oak. It sometimes attains a diameter of two inches. It begins to form as soon as the leaves unfold. It is at first green and pulpy and has a central kernel in which the maggot resides. When the gall is ripe the shell becomes hard and dry, and after the fly has escaped, which occurs in June and again in October, the deserted shell is often tenanted by wasps. Some galls, as the bedeguar of the rose, are covered with vegetable hairs, and the variety of form in others is very great. On the raspberry and blackberry, as well as the blueberry, occur different sorts of galls. All are the result of the sting of the female, which is thought by some to convey a poison into the wound, though it is a question whether the egg introduced by the sting or ovipositor does not act as an irritant body, causing an excessive flow of sap and accumulation of cells resulting in the formation of a tumor.

Passing by the ichneumon flies, which after all have the best of it, as they are tenants of living homes, supplied with the choicest of food at no trouble and expense to themselves, we come to the cuckoo flies. The Chrysis (Fig. 245) is not a true wasp, but is in some respects allied to it. Its integument is very hard and thick, and beautifully tinted with green and blue and various metallic colors. When assailed it rolls itself into a ball, in the manner of a pill bug. Its sting is large and exceedingly painful, but not poisonous. The Chrysis is called a cuckoo fly, as it has the ichneumon trait of living at the expense of other insects. This fly may often be seen flying about posts and hollow stalks of plants, exploring the holes of wasps and bees, where they lay their eggs. The young hatch out some time after the larval bee or wasp, and then attack the latter, sucking its

FIG. 245.



Chrysis.

blood. The patience and perseverance under great natural difficulties, the danger to which they are exposed from the attacks of their unwilling hosts would form an interesting chapter, but we must come now to the true builders.

The ants are their own architects, their own masons and laborers. I shall not now speak of their colonies and complex mode of life. It is well known that the workers carry on the labors of the colony, and to these beings, which have not the power of transmitting their qualities, but inherit them from their parents, has been imparted a high degree of skill, in fact, somewhat of those qualities which characterize the highest types of human civilization; for, while ants are fully capable of defending themselves, and as every body knows are bold and aggressive to a fault, they also excel in the arts of peace.

FIG. 246.

Driver Ant.

As bridge-makers they have anticipated our civil engineers. The driver ants, Anomma (Fig. 246), which are blind, are said by Dr. G. A. Perkins, who has observed them in Western Africa, to "often bridge narrow streams of water when these come across their path, by going in large numbers upon a flexible plant on one side of a stream, until their weight causes it to bend to the other side." This ant is certainly equal, in this respect at least, to the monkeys which are said to cross streams in a similar manner.

But it is in the construction of underground tunnels that ants are preëminent. The late Gideon Lincecum, so well known for his acute powers of observation, in an account of the *Œcodoma Texana* states that "they often carry their subterranean roads for several hundred yards in grassy districts, where the grass would prove an impediment to their progress. On one occasion, to secure access to a gentleman's garden, where they were cutting the vegetables to pieces, they tunnelled beneath a creek which was at that place fifteen or twenty feet deep, and from bank to bank

about thirty feet. Another species in Brazil, according to Rev. Hamlet Clark, will tunnel a ditch, and he adds, "Indeed, I have been assured again and again by sensible men, that it has undermined, in its progress through the country, the great river Paraiba, as broad as the Thames at London Bridge; at any rate, without anything like a natural or artificial bridge, it appears on the other side and continues its course."

It would be exceedingly interesting to watch the successive steps of this tunnelling process, to learn how they plan their work, how the mine is run under the stream with such true engineering skill from one side to the other; how the danger of undermining and flooding are overcome. Here we have a slight anticipation of the Thames tunnel, though this is said to have been suggested by the tunnel of the ship worm, which lines its hole with limestone.

Ants also dig wells. The same Texan Œcodoma, we are told by Dr. Lincecum, needs water as much as cattle or men, and like the latter they dig their own wells. In one case, where a man dug a well reaching water at a depth of thirty feet, the ants dug a well to the same depth, with a diameter of twelve inches.

As mound builders the ants are indefatigable. With the aid of their jaws they carry out grain after grain of sand, and from being primarily tunnellers, they become mound-builders. An ant hill, common object as it is, is a marvel of patient and untiring labor. Think of the toil and muscular exertion spent by these ants in climbing from the depths below up the perpendicular walls of their nests with their burdens; and busy as they appear to us by day, they are said to do the greater part of their work by night. In clayey countries in Mexico the Œcodomas build enormous ant hills, "so that one perceives them from afar by the projection which they form above the level of the soil, as well as by the absence of vegetation in their immediate neighbor-

hood. These nests occupy a surface of many square metres, and their depth varies from one to two metres." (Sumichrast.)

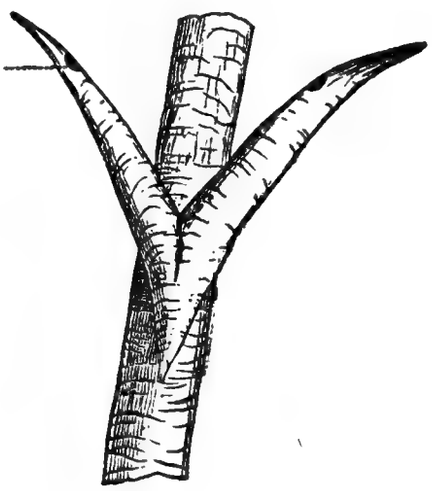
The exact height of these ant hills is not stated. The largest earthen nests of which we have any account are those described by the Jesuit Dobrizhoffer and alluded to by Westwood in his "Introduction to the Modern Classification of Insects." The conical nests of these ants, which abound in the plains of Paraguay, are said to be as hard as stone and "three or four ells high." A Flemish, English and French ell are three, five and six quarters of a yard respectively; which measurement is intended by the Portuguese writer or Prof. Westwood is not stated. By English measurement the hills would be about twelve feet high. This is the only case where the hills of the ants emulate in size those of the Termites. Our largest native nests are made by the *Formica sanguinea*, or common large red ant, and consist of sand or clay, according to the nature of the ground. Undoubtedly the object of the ants in making the hills is to keep the water out of their burrows, but in Labrador, where it rains nearly every other day, I have observed that this or an allied species makes no hillocks, but lives exclusively in underground passages.

Another kind of ant attains a still higher degree of civilization. The Agricultural ant of Texas, studied for so many years by Dr. Lincecum, is said by him (in the "American Naturalist") to build paved cities and construct roads. In a year and a half from the time the colony begins, the ants previously living concealed beneath the surface, appear above and "clear away the grass, herbage and other litter to the distance of three or four feet around the entrance to their city, and construct a pavement, ... consisting of a pretty hard crust about half an inch thick," formed of coarse sand and grit. These pavements would be inundated in the rainy season, hence, "at least six months previous to the coming of the rain," they begin to build mounds rising a

foot or more from the centre of the pavement. Within these mounds are neatly constructed cells into which the "eggs, young ones, and their stores of grain, are carried in time of rainy seasons." In another place he adds that "some old settlements have a pavement fifteen feet in diameter and a mound in the centre a foot high." The roads extend for half a mile from the "formicary," or ant hill.

One kind of Mexican ant (*Pseudomyrma flavidula*) is known to live within the spines of the Mimosa, the hole for the entrance and exit of the ants being made near the end (Fig. 247, *a*).

FIG. 247.



Ant nest in thorns.

In India, a greenish ant (*Œcophylla smaragdina*) is said by Jerdon to form a nest, sometimes a foot in diameter, by drawing living leaves together without detaching them from the branch, and uniting them with a fine white web. Another Indian ant, like the paper wasp, "makes a small nest about half an inch, or rather more, in diameter, of some papyraceous material, which it fixes on a leaf." (Jerdon.) The ants belonging to the genus Crematogaster, and which from their resemblance to a wig are known by the popular name of "Negro-head" in Brazil, according to Mr. F. Smith, "construct their nests on the branches of trees, suspending them in the same way as wasps, to the nests of which they have a close resemblance; on removing the outer covering, however, they exhibit a very different construction, being composed of multitudinous, curved, intricate ramifications, all leading to the interior chambers and galleries."

There are many sand wasps which excavate holes in the ground, and deposit at the bottom of their burrow living but paralyzed insects among which they lay their eggs. A

typical example is the Sphex (Fig. 59) whose habits have already been described. The mud dauber (*Pelopœus flavipes*) is a slender form, brightly banded and spotted with yellow, and is found all over the country. Her cells of pellets of mud plastered on the wall of a house are common objects known to every school boy. These cells are built of layers of mud of unequal length, the pellets being placed in two rows, diverging from the middle. They are a little over an inch in length and about half as wide, and are seen in section to be triangular in outline. The larva within spins a brown silken cocoon, after eating up the store of paralyzed spiders, whose remains may often be found tucked away at one end of the cell. Several cells usually occur together, covered over with a common layer of mud.

This habit of collecting materials for their nests is shown more distinctly in the black Sphex (*S. tibiàlis*) which forms its nest in the tunnels previously made by the carpenter bee in a piece of pine board. In an example described in my "Guide to the Study of Insects," the hole was six inches long, and the oval, cylindrical cocoons were packed loosely, either side by side, where there was room, or in a single row. The interstices between them were filled with bits of rope, which appeared as if they had been bitten in pieces by the wasp itself, while the end of the cell was filled for a distance of two inches with a coarse sedge arranged in layers, as if rammed in like gun wadding.

Another exception to the burrowing habits of the sand wasps is afforded by a Brazilian species of Larrada, which, according to Mr. Bates, builds a nest "composed apparently of the scrapings of the woolly texture of plants; it is attached to a leaf, having a close resemblance to a piece of German tinder, or a piece of sponge." In thus availing itself of the scrapings of the bark of plants, we have a slight anticipation of the paper-making wasps. The wood wasps evince fully as much, if not more, architectural skill

than the sand wasps. The different species of Crabro, with their large cubical heads, the Philanthus (Fig. 248) and Cerceris, refit old nail holes and tunnel rotten wood, filling their holes with aphides, caterpillars, beetles and spiders, etc. The European *Philanthus apivorus* has the unfortunate habit of provisioning its nest with honey bees; so also with a species of Cerceris. The smaller, blackish species have the most interesting habits. In Europe, according to Prof. Westwood, the prey of a species of Oxybelus consists of flies, "which it has a peculiar mode of carrying by the hind legs the while it either opens the aperture of its burrow, or else forms a new one with its anterior pair."

FIG. 248.

Philanthus.

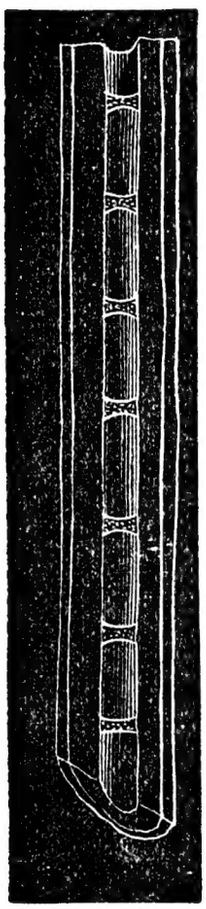
A Trypoxylon wasp was detected in England frequenting the holes of a post preoccupied by a species of Odynerus, a solitary wasp closely allied to the social paper wasps, "into which it conveyed a small round ball, or pellet, containing about fifty individuals of a species of Aphis; this the Odynerus, upon her return, invariably turned out, flying out with it, held by her legs, to the distance of about a foot from the aperture of her cell, where she hovered for a moment, and then let it fall; and this was constantly the case till the Trypoxylon had sufficient time to mortar up the orifice of the hole, and the Odynerus was then entirely excluded; for although she would return to the spot repeatedly, she never endeavored to force the entrance, but flew off to seek another hole elsewhere." The stems of the syringa, elder, blackberry and other pithy shrubs are also favorite nesting places of these wood wasps. Several species have been found by Mr. Angus nesting in the stems of the syringa; all their nests have a family resemblance, being simple tunnels, without any pretensions to architectural skill.

The stems of the blackberry or syringa are often tenanted by the little green Ceratina bee. Figure 249 represents a

syringa stem containing the cells of this bee, separated at regular intervals by little parchment partitions, the spaces between them being filled with dirt. The cells are filled by the parent bee with pollen, a store of food for the grub.

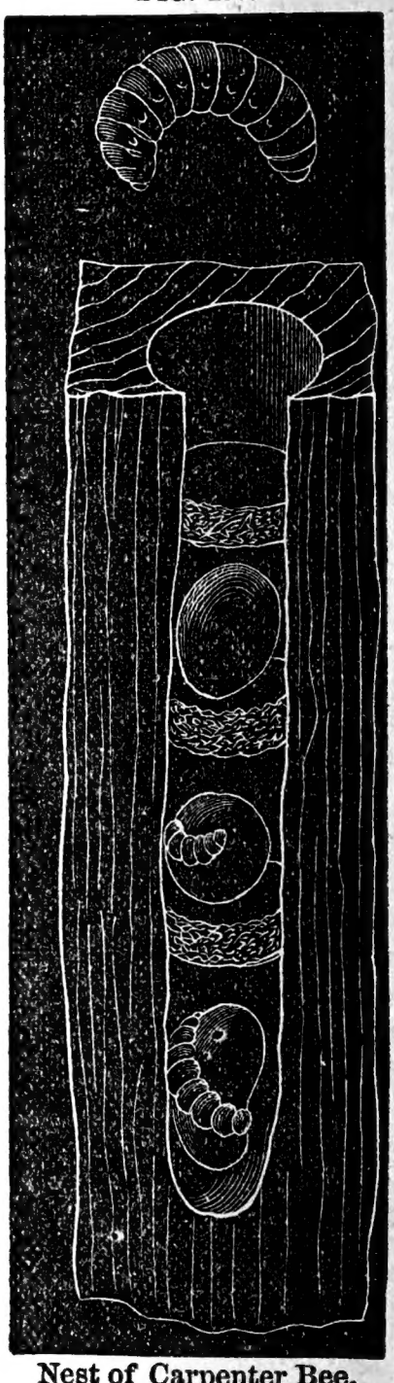
A great step in advance is the home of the carpenter bee (Fig. 250), which is bored in solid pine wood or even hard wood, sometimes for a foot or more. The work is done by the jaws of the bee, and the hole is bored as evenly as by an auger. After boring the hole, it is partitioned off by chip walls, a pellet of pollen on which the larva feeds having been previously placed in each cell. Here is a specimen of mechanical ingenuity and architectural skill which is certainly surprising, and indicates some forethought and a certain degree of reasoning power.

FIG. 249.



Nest of Ceratina.

FIG. 250.



Nest of Carpenter Bee.

In the succeeding chapter the nests of the social wasps and bees will be noticed, as the high degree of architectural skill shown by these insects is intimately related with the complex economy of the colony.

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